INTELLIGENT TRAFFIC LIGHTS BASED ON ARTIFICIAL INTELLIGENCE

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ABSTRACT

Rapid population growth and the increasing demand for transportation have led to a pervasive issue of traffic congestion in various cities, with Houston, Texas, USA, being notably affected. The consequences of congestion, whether direct or indirect, impact our daily lives significantly. These consequences encompass loss of productive hours, higher accident rates, road rage incidents, environmental pollution, and unpredictability in travel times. The continued rise in traffic necessitates innovative solutions like Artificial Intelligence (AI) for improved signal control and efficient traffic management. Among the fundamental components governing traffic flow, traffic controllers play a crucial role. Similar to advancements in electronics, traffic lights must evolve to address the evolving challenges of congestion and population growth. One proposed solution involves real-time data collection through cameras positioned at traffic intersections. AI and image processing technologies can be leveraged to analyze these images, enabling the determination of traffic density and facilitating real-time traffic direction based on vehicle volume. The key innovation lies in transforming individual traffic lights within a specific zone or area into a synchronized system managed by a central control unit. This approach results in a unified and efficient traffic management system. By implementing such a system, cities can better respond to the growing demands of their transportation networks, alleviate congestion, and enhance the overall commuting experience for residents. This integrated approach represents a strategic and technology-driven solution that harnesses the power of AI and real-time data to optimize traffic management, making it responsive to the challenges presented by rapid urbanization and increased vehicular traffic. In doing so, it aims to improve the quality of life for residents by reducing the negative impacts of congestion and enhancing the efficiency of urban transportation.

KEYWORDS: Artificial Intelligence, Traffic Light, Traffic management and Image processing.

INTRODUCTION

One of the most crucial factors in the development of any country is transportation since it is key to promoting economic growth, creating jobs, and connecting people to necessary services like healthcare and education. However, the addition of additional vehicles is a global issue that is contributing to an increase in traffic congestion year over year. The largest of the 48 states that make up the United States, Texas is located in the South-Central region of the country along the border with Mexico. Texas currently has the third-highest growth rate in the country at 1.8%, (Review, 2017), (Bureau, 2014). Texas has just 105.2 people per square mile, which ranks as the 26th highest population density in the US. Dallas, Houston, and San Antonio, three cities in Texas with populations of one million or more each, are among the ten most populated cities in the US. Along with being three of the top 25 largest US cities.

Figure 1: Texas estimate population chart of year 2021 [2].

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Figure 2: Houston cumulative population change [2].

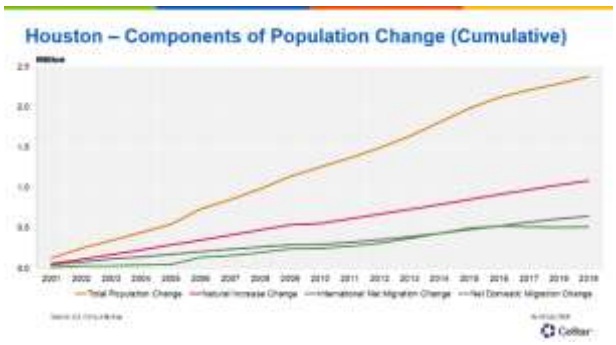


Figure 2: Houston cumulative population change [2].

In Texas, the issue of traffic congestion has developed into a significant real-time transportation issue. To assess and solve this issue, effective intelligent solutions must be employed. A traffic signal that is integrated with other systems, such as CCTV cameras, automated lane closure systems (ALCS) to reroute traffic, and other systems, will be the fundamental element of this approach. This system, which can identify areas of excessive traffic, can show a timetable of which lanes are congested at what times. The use of monitoring and detecting algorithm enables the analysis of on-road circumstances. Decision-making or the identification of connections can be

done using the information gathered. For instance, checking the lanes during peak hours or keeping track of the number of drivers during specific hours. In managing various data sources like images from CCTV, loop detector etc. AI can automatically analyze these data and learn from these data. we can then use AI to control, direct and manage traffic efficiently.

BACKGROUND OF STUDY

Traffic lighting has been used for centuries, and since the first traffic light was invented in the 1800s, the technology has continued to advance. Traffic lighting was invented long before cars were frequently used as a mode of transportation. Gas fueled traffic signals were invented in the 1860s by British railway engineer J. P. Knight to manage traffic between horse-drawn carriages and pedestrians. This idea, however, was not particularly successful because of a risk it posed that tragically resulted in a police officer in charge of the traffic lights suffering serious injuries from an explosion caused by gas leaks, making the invention unfit for use. Traffic control was greatly needed because of the quick and widespread adoption of the automobile as a mode of transportation. The first electric traffic light was invented in 1900 by L. F. Wire, a police officer from Salt Lake City in the United States. This traffic signal only contains red and green lights for pass and stop, although it previously had a ready buzzer which had now been replaced with amber in modern traffic lights. William L. Potts was the first to invent three lights, four ways traffic light using red, amber and green. Although there are several designs at that time but all was manually controlled systems. Houston was part of the first to use synchronized electric traffic lights. The invention of computers leads to better performance of traffic light as in middle 1900s, computerized traffic lights were invented which is smarter than the previous traffic light system. In addition, in late 90s count down traffic light was also invented which is very useful till today because drivers and pedestrians know stop time or pass time improving people's patient. Nearly all significant intersections in cities and towns across Texas have traffic lights to manage the flow of traffic. Their primary function is to control traffic, and they have been doing so well for the past years. However, as population levels rises and the number of vehicles on our roads rises, the traffic lights' limitations become more apparent, and they have begun to fail. On the other hand, we may overcome these drawbacks brought on by developing technology and improve the functionality of traffic lights so that they can manage traffic flow more effectively. One of the new terms emerging in technology that is being used at various places is Artificial Intelligence (AI). Among the many problems to be solved by this technology, it has been described as the next big wave of smart technology. Systems that can execute activities that typically require human intelligence are created in the interdisciplinary field of artificial intelligence (AI), (R. Stuart and N. Peter 2020). A variety of human tasks can be performed by them, including speech recognition, learning, planning and problem solving. AI system can also mimic human brain functions like reasoning, perception etc. The concept of machine learning is one of the key components of artificial intelligence. Machine learning refers to a set of algorithms that can be used to improve the predictability of software programs and artificial intelligence without being specifically designed to meet specific needs. In other words, AI computers can compute results based on input, recognize patterns, and make decisions without involving humans. Additionally, it can update the result when new input data becomes available (Erwin, Walraven 2021). It is crucial to look into what AI

can accomplish for traffic control system and its management at this crucial time because AI is currently the subject of intense scientific research and applications are being developed across a variety of sectors. In order to enable automatic driving, a lot of research is now being done in the field of pattern recognition. AI has provided opportunities to control and management traffic in more efficient way.

PROBLEM STATEMENT

A typical traffic signal system comprises several components, including a controller, traffic light heads, and, occasionally, detection mechanisms. The controller serves as the system's central intelligence, utilizing preprogrammed data to manage the sequencing of traffic lights. The most common traffic lights typically operate on straightforward timers, which cyclically transition through the colors green, yellow, and red to maintain a consistent flow of traffic at the intersection. However, this conventional method has limitations, particularly in areas with high traffic density, such as Houston, where traffic patterns can be erratic and unpredictable. Timed cycles remain static, regardless of the prevailing traffic conditions. This approach may inadvertently impede traffic flow or prove inefficient when, during certain cycles, no vehicles await passage, wasting valuable time that could be more effectively utilized in addressing congestion in congested lanes.

These limitations lead to a series of undesirable consequences, including:

- Potentially impeding the flow of fast-moving traffic.
- Allowing vehicles to pass through empty lanes.
- An increased likelihood of traffic law violations.
- Wastage of money, fuel, and valuable man-hours.
- Requiring pedestrians to wait unnecessarily, even when no vehicular traffic is present.
- Fostering a sense of aggressiveness and impatience among drivers.

LITERATURE REVIEW

When an intersection is busy, traffic signals are the most practical way to control traffic. We can observe that these signals are not functioning adequately when one lane has more traffic than the other lanes. Our solution to this problem will be smart traffic lights instead of conventional traffic lights, (M. T.J.A, 2018). A method smart traffic light that uses a wireless communication channel to manage the signal lights and chooses the closest way with the least amount of congestion, traffic junction dangers will be reduced, (M. T.J.A, 2018). Depending on the number of roads at intersections, cameras will be installed. A frame-by-frame analysis of vehicle traffic flow on a road will be done using a high-definition camera mounted on poles. Using established technology and real-time video processing, we can determine the number of cars on the road (A. Choudhary 2018). Using a sequential traffic timer system that is dependent on car counts. The sequential traffic lights will begin when the microcontroller detects a signal from the CPU. A signal will be sent to the CPU by the microcontroller or Arduino as the light phase changes from green to red. CPU compares both roads' vehicle counts after that. The road with the most traffic will be given preference, and the green light will be on there while the other route automatically receives a red signal (A. Choudhary 2018). In order to change how

drivers, behave, a number of tests were conducted as part of the Brabant In-Car initiative. While traveling on the A67, drivers received individualized information on their smartphone or navigation device. One of the adopted is Smoover. A collection of Brabant In-Car program projects. In order to improve traffic flow on the A67, a navigation app for cellphones was created during this project that offered speed guidance to drivers. The basic mechanisms of Smoover utilized two AI techniques. Based on past data and current data from the A67, deep learning was applied to forecast traffic. These forecasts enabled proactive speed recommendations depending on the anticipated conditions on the road. Furthermore, reinforcement learning was applied during simulations to discover which speed recommendations have a favorable impact on traffic flow (Erwin, Walraven 2021). (J. Hyunjeong, L. Jincheol and S. Keemin, 2017.) used a reinforcement learning (RL) model for adaptive traffic signal control using video from intersection cameras. An image-based RL model outperformed both the real functioning of fixed signals and a fully actuated operation, and footage from aerial video frames fully addressed the traffic status of an independent 4-way intersection.

STYLISED FACTS ON INFORMATION RELATING TO TRAFFIC SAFETY ADMINISTRATION

Using data from the National Highway Traffic Safety Administration (NHTSA), The Houston Chronicle approximated the number of fatal drunk driving accidents that occurred in 12 American metropolitan areas between 2001 and 2016 (). W. Brian, (2018). In addition to the 91,388 fatal accidents in which alcohol played a substantial role, it looked at 23,314 fatal incidents in which drug intoxication was a factor. The research by The Chronicle revealed the following results: The majority of drunk driving collisions take place in Texas. In Harris County, Houston had the lowest percentage of DWI accidents. 944 fatal accidents involving drunk drivers occurred in California in 2017. Of all the US urban areas, the nine-county Houston area reported the most fatalities. Texas DWI accidents claimed the lives of 1,018 people in 2016. Houston is the US city with the highest number of deadly drunk driving accidents. In the Houston area, there are frequently more than 300 fatal DWI events per year.,More than 3,000 fatal DWI accidents occurred in Houston over a 16-year span, which is three times as many as Los Angeles, which has nearly twice as many residents as Houston. In the Houston region, there have been more than 5,000 drunk driving accidents per year since 2010. This equates to 14 DWI accidents on average every day. With 2,425 accidents involving intoxicated drivers between 2001 and 2016, Dallas/Fort Worth was second in the US. 2,325 DWI fatalities in Houston were caused by alcohol-related incidents during the course of the inquiry, whereas 708 were caused by drug-related incidents. Since 2015, more than 70 Precinct 8 Constable's Office officers have stopped about 1,400 drunk drivers. This is the sixth-highest number of DWI arrests in the county. Of the 30,000 drunk drivers arrested in America in 2015, nearly 8,000 (26.6%) were repeat offenders with prior DWI convictions. Weekend DWI incidences (Friday, Saturday, and Sunday) account for two thirds of all accidents in Texas. On any day of the week, Saturday has the highest percentage of accidents involving intoxicated drivers (23,1%). The issue of drunk driving appears to be out of control in Houston. Instead of declining, drunk driving is on the rise in Texas. In April 2018, the Houston Police Department arrested 36 people for felony DUIs. The other 14 were charged with DWI with minor passengers, while two of these perpetrators were

charged with drunken manslaughter. The problem is exacerbated by a dearth of law enforcement tools. Driving that is illegal and reckless is the other problem.

A HOUSTON DRIVER'S GUIDE TO SAFE DRIVING

In Houston, there is a fairly significant likelihood that a driver will be involved in a drunk driving collision. You run the risk of getting hurt if you operate a vehicle in the region while impaired by alcohol, narcotics, or prescription medications that might have negative side effects. The following behaviors can be used to detect intoxication: accelerated or decelerated quickly; failing to keep one lane open; ignoring stop signs or red lights; driving practically against the windshield. If you notice any signs that a driver is impaired, keep your distance and contact the police. Avoid driving after midnight as these collisions seem to happen more frequently at night in Texas than during the day. Get in touch with a drunk driving accident lawyer if a drunk driver hits you and causes serious injury. These crash hotspots enhance the risk of car accidents in Houston for a variety of reasons. These include, but are not limited to: Limited visibility as a result of the roadways' design and curves, as well as parking lots, vegetation, medians, and other roadside features. The number of information that drivers must keep in mind while operating a vehicle increases when there are several lanes of traffic, which complicates traffic situations.

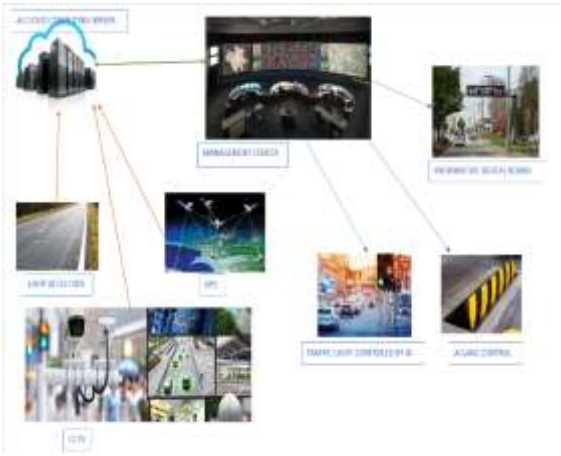
METHODOLOGY

In Houston most junction traffic light works based pre-programed timer which is not efficient any more for traffic flow control. This research proposed using AI to enhance the effectiveness of traffic flow control leading to betterment of traffic management. The system will be categorized into:

- Monitoring and detecting.
- Informing, advising and warning.
- Management and control.

There are input devices cameras set in the ideal location of the intersections to record video footage for monitoring and detection. This camera will have AI functionality since most CCTV already has machine learning features like object detection, face detection, etc. Additionally, GPS, Loop Detectors, and other detection and monitoring tools will in real-time interface with the cloud server, where it will go through a number of AI algorithms to learn, suggest, and enhance the flow of traffic. There will be redundancies in the system to prevent system failure during outages even though all junctions will be operated as one system with a self-learning server managing the traffic. This system will be able to see traffic from above in an area with intersections and make the appropriate decisions, such as turning the light on in accordance with requirements. It will also continuously learn about peak times, reckless driving, drivers on their phones, improper parking, etc. The system will be able to issue announcements via digital billboards with informative content advising and warning vehicles, pedestrians, and even forbidding overtaking when necessary. In order to respond quickly to issues, the system can alert the incident management department.

Figure 3: Proposed method overview



CONCLUSION

Currently, artificial intelligence (AI) is at the forefront of conversations, regarded as a suite of technologies that empowers innovative applications across various domains. AI either provides essential support to individuals or autonomously executes processes. In the context of traffic management, AI plays a pivotal role in enhancing efficiency, bolstering the economy, and ultimately enhancing the quality and productivity of our daily lives.

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